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UNIVERSITY OF CALIFORNIA

July 10, 1964

LAWRENCE RADIATION LABORATORY
P. O. BOX 808
LIVERMORE, CALIFORNIA

Dr. Donald Rea
Space Science Board
National Academy of Sciences
800 Welch Road - Suite 214
Palo Alto, California

Dear Dr. Rea:

This note is intended as a preliminary reply to Prof. Lederberg's letter of June 29 regarding the analysis of the Martian surface. He has divided the problem into three questions dealing with the detection of life, the determination of its nature if present, and the properties of the environment in which it is found. I will try to state briefly how neutron activation analysis might be applied to these problems. In a few weeks, I will submit a more detailed report suggesting how some of the specific experiments discussed here might be performed.

1) Diagnosis of the Presence of Life. Neutron activation analysis is almost certain to be useless for this purpose. Neutron analysis methods can be used to detect the presence of many nuclear species (sometimes even if they are present only in very minute quantities) but they cannot determine the detailed chemical combinations of the elements present. Sometimes, certain conclusions can be drawn about the chemical composition of the sample from the abundance ratios of the elements. However, in the case of organic or living matter this is very unlikely. Unfortunately, the most important elements in living matter (carbon, oxygen, nitrogen and hydrogen) are relatively difficult to detect by nuclear methods. It is very improbable that a neutron activation analysis experiment could be performed with sufficient accuracy to tell the difference between "living" and "inert" organic matter. (I am not even certain whether significant differences in gross composition exist between "inert" materials such as starch and living proteins.) Thus, for the detection of living matter, other methods will have to be employed.

2) Nature of Life if Present. This question also is probably one for which nuclear activation methods are inapplicable. The "nature" of living matter depends even less on gross chemical composition and more on rather subtle differences in the structure of complex protein molecules. Nuclear analysis methods are thus even less useful in this case than they are for detecting the presence of living matter. There is one application in this connection for which certain radioactive sources might be useful. Suppose that a certain bio-chemical experiment is devised to detect the presence of a certain species by measuring the products of the metabolic process (say CO_2). Radio isotope (specifically, strong α-particle sources) could be employed to deliver strong radiation doses to the suspected "living" sample to see whether the metabolic rate can be changed or even halted. Although I am not entirely certain of this point, it seems to me that a unique feature of "living" matter which could be used to establish its presence is that it can be killed relatively easily. Radiation doses are by far the cheapest

3) Nature of the Martian Environment. This problem is the only one of the questions asked by Prof. Lederberg where nuclear methods may have wide applications. For example, it is possible to obtain a relatively good analysis of soils using nuclear methods. Both the scattering of fast neutrons (with observation of prompt gamma rays produced in inelastic collisions) and the more standard neutron activation methods can be employed. Several flight packages are now under construction designed for the remote analysis of the lunar surface. These payloads are intended for use with the "Surveyor" series space craft. The flight-hardened and environmentally tested instrument packages weigh somewhere between ten and thirty pounds. It is very probable that, with perhaps minor modifications, these packages could be used as they are for an analysis of the Martian surface. For example, inelastic scattering experiments with fast neutrons could be most useful in establishing that iron is a prevalent element on the planet's surface. The most abundant isotope of this element has a particularly large inelastic scattering cross section and a very conspicuous gamma ray (at 850 keV) which is easy to observe. I am enclosing some reprints which describe the possibilities of the method. (In addition, I have asked Dr. James A. Waggoner, who developed the neutron scattering experiment to provide more detailed information for you.)

In summary, I would say that neutron analysis methods are not likely to be useful in actually detecting the presence of life on Mars. However, they may provide the best means for establishing some pertinent facts about the nature of the Martian environment.

Very sincerely yours,

Hans Mark

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